METHOD, APPARATUS AND ARTICLE FOR RANDOM SEQUENCE GENERATION AND PLAYING CARD DISTRIBUTION

BACKGROUND OF THE INVENTION

Technical Field

This invention is generally related to games of skill and chance, and in particular to distributing playing cards for card games.

Description of the Related Art

Card games are a well-known form of recreation and entertainment. Games are typically played with one or more decks of cards, where each deck typically includes 52 cards. Each deck of cards will typically include four suits of cards, including: hearts, diamonds, clubs, and spades, each suit including fourteen cards having rank: 2-10, Jack, Queen, King and Ace. Card games may, or may not, include wagering based on the game's outcome.

Decks of playing cards must be periodically shuffled to prevent the same card hands from continually reappearing. Shuffling may take place after every card in the deck or decks has been dealt, for example after several hands have been played. Shuffling may also interfere with, and even prevent, a player from gaining an unfair advantage over the house or other players by counting cards. Numerous card counting systems are known, and typically rely on a player keeping a mental count of some or all of the cards which have been played. For example, in the game of twenty-one or "blackjack" it is beneficial to determine when all cards with a rank of 5 have been dealt (*i.e.*, fives strategy). Tens strategy is another card counting method useful in the game of twenty-one. In tens strategy, the player increments a count each time a card having a value of 10 appears, and decrements the count when card having a value less than appears. The count may be divided by the total number of cards remaining to be dealt to give the player an indication

of how much the remaining deck favors the player with respect to the house. Other variations of card counting are well known in the art.

Manual shuffling tends to slow play down, so the gaming industry now employs numerous mechanical shufflers to speed up play and to more throughly shuffle the cards. The cards are typically shuffled several cards before the end of the deck(s), in an effort to hinder card counting, which may be particularly effective when only a few hands of cards remain (*i.e.*, end game strategy). The ratio of the number of cards dealt to the total number of cards remaining in the deck(s) is commonly known as the penetration. The gaming industry is now introducing continuous shufflers in a further attempt to frustrate attempts at card counting. As the name implies, continuous shufflers mechanically shuffle the cards remaining to be dealt while one or more hands are being played.

While mechanical shufflers increase the speed of play and produce a more through shuffle over manual methods, there is still a need for improve in speed and/or thoroughness of the shuffle. In particular, mechanical shuffling methods are subject to incomplete shuffles due to the inherently mechanical nature of such devices. Additionally, mechanical shufflers are limited in the total number of decks they can manipulate.

SUMMARY OF THE INVENTION

Under one aspect, a method, apparatus and article generates a pseudo-random playing card sequence, and distributes playing cards according the pseudo-random playing card sequence.

In another aspect, a method, apparatus and article generates a pseudo-random playing card sequence, and prints playing cards in order of the pseudo-random playing card sequence.

In a further aspect, a method, apparatus and article generates a pseudo-random playing card sequence based on a house advantage.

In yet a further aspect, a method, apparatus and article generates a promotional message on one or more playing cards.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, identical reference numbers identify similar elements or acts. The sizes and relative positions of elements in the drawings are not necessarily drawn to scale. For example, the shapes of various elements and angles are not drawn to scale, and some of these elements are arbitrarily enlarged and positioned to improve drawing legibility. Further, the particular shapes of the elements as drawn, are not intended to convey any information regarding the actual shape of the particular elements, and have been solely selected for ease of recognition in the drawings.

Figure 1 is an isometric view of a networked automatic wager monitoring system in a gaming environment, including a networked playing card distribution device according to one illustrated embodiment of the invention.

Figure 2 is an isometric view of a gaming table, including a standalone playing card distribution device according to another illustrated embodiment of the invention.

Figure 3 is a functional block diagram of the networked automatic wager monitoring system of Figure 1.

Figure 4 is a cross-sectional diagram of one embodiment of the playing card distribution device in the form of a card printing device, particularly suited for the standalone operation of Figure 2.

Figure 5 is a front elevational view of a face of an exemplary playing card.

Figure 6 is a schematic diagram of another embodiment of a card printing device, particularly suit for use with the automatic wager monitoring system of Figure 1.

Figures 7A-7B are a flow diagram showing a method of operating the host computing system of Figure 1 and the card distribution device of Figure 6.

Figures 8A-8B are a flow diagram showing a method of operating the card distribution device of Figure 4.

DETAILED DESCRIPTION OF THE INVENTION

In the following description, certain specific details are set forth in order to provide a thorough understanding of various embodiments of the invention. However, one skilled in the art will understand that the invention may be practiced without these details. In other instances, well-known structures associated with computers, servers, networks, imagers, and gaming or wagering apparatus have not been shown or described in detail to avoid unnecessarily obscuring descriptions of the embodiments of the invention.

Unless the context requires otherwise, throughout the specification and claims which follow, the word "comprise" and variations thereof, such as, "comprises" and "comprising" are to be construed in an open, inclusive sense, that is as "including, but not limited to."

The headings provided herein are for convenience only and do not interpret the scope or meaning of the claimed invention.

Wagering Environment Overview

Figure 1 shows a networked automated wager monitoring system 10 including a host computing system 12, a server 14 and a network 16. The server 14 and network 16 couple the host computing system 12 to various gaming sensors, gaming actuators and/or gaming processors at a number of different wagering or gaming tables, such as a twenty-one or blackjack table 18.

In one embodiment, the host computing system 12 acts as a central computing system, interconnecting the gaming tables of one or more casinos. In an alternative embodiment, the host computing system 12 is associated with a single gaming table, or a small group of gaming tables. In a further alternative, the host computing system 12 is associated with a single gaming table or group of gaming tables and is interconnected with other host computing systems.

The gaming sensors, gaming actuators and/or gaming processors and other electronics can be located in the gaming table, and/or various devices on the gaming table such as a chip tray 22 and/or a card distribution device 24. For example, suitable hardware

and software for playing card based games such as twenty-one are described in commonly assigned pending U.S. patent applications: Serial No. 60/130,368, filed April 21, 1999; Serial No. 09/474,858, filed December 30, 1999, entitled "METHOD AND APPARATUS FOR MONITORING CASINO GAMING" (Atty. Docket No. 120109.401); Serial No. 60/259,658, filed January 4, 2001; Serial No. 09/849,456, filed May 4, 2001 (Atty. Docket No. 120109.402); and Serial No. 09/790,480, filed February 21, 2001, entitled "METHOD, APPARATUS AND ARTICLE FOR EVALUTING CARD GAMES, SUCH AS BLACKJACK" (Atty. Docket No. 120109.403).

A player 26 can place a wager on the outcome of the gaming event, such as the outcome of a hand of playing cards 28 dealt by a dealer 30 in a game of twenty-one. The player 26 may place the wager by locating wagering pieces such as one or more chips 32 in an appropriate location on the blackjack table 18.

Figure 2 shows an alternative embodiment of the gaming table 18. This alternative embodiment, and those alternative embodiments and other alternatives described herein, are substantially similar to previously described embodiments, and common acts and structures are identified by the same reference numbers. Only significant differences in operation and structure are described below.

In Figure 2, the gaming table 18 includes a standalone version of the card distribution device 24, and otherwise does not employ the electronics of Figure 1. Thus, the dealer and/or pit boss manually monitors the game play and wagering.

System Hardware

Figure 3 and the following discussion provide a brief, general description of a suitable computing environment in which embodiments of the invention can be implemented, particularly those of Figure 1. Although not required, embodiments of the invention will be described in the general context of computer-executable instructions, such as program application modules, objects, or macros being executed by a computer. Those skilled in the relevant art will appreciate that the invention can be practiced with other computer system configurations, including hand-held devices, multiprocessor systems,

microprocessor-based or programmable consumer electronics, personal computers ("PCs"), network PCs, mini computers, mainframe computers, and the like. The invention can be practiced in distributed computing environments where tasks or modules are performed by remote processing devices, which are linked through a communications network. In a distributed computing environment, program modules may be located in both local and remote memory storage devices.

Referring to Figure 1, a conventional mainframe or mini-computer, referred to herein as the host computing system 12, includes a processing unit 34, a system memory 36 and a system bus 38 that couples various system components including the system memory 36 to the processing unit 34. The host computing system 12 will at times be referred to in the singular herein, but this is not intended to limit the application of the invention to a single host computer since in typical embodiments, there will be more than one host computer or other device involved. The automated wager monitoring system 10 may employ other computers, such as conventional personal computers, where the size or scale of the system allows. The processing unit 34 may be any logic processing unit, such as one or more central processing units (CPUs), digital signal processors (DSPs), application-specific integrated circuits (ASICs), etc. Unless described otherwise, the construction and operation of the various blocks shown in Figure 1 are of conventional design. As a result, such blocks need not be described in further detail herein, as they will be understood by those skilled in the relevant art.

The system bus 38 can employ any known bus structures or architectures, including a memory bus with memory controller, a peripheral bus, and a local bus. The system memory 36 includes read-only memory ("ROM") 40 and random access memory ("RAM") 42. A basic input/output system ("BIOS") 44, which can form part of the ROM 40, contains basic routines that help transfer information between elements within the host computing system 12, such as during start-up.

The host computing system 12 also includes a hard disk drive 46 for reading from and writing to a hard disk 48, and an optical disk drive 50 and a magnetic disk drive 52 for reading from and writing to removable optical disks 54 and magnetic disks 56,

respectively. The optical disk 54 can be a CD-ROM, while the magnetic disk 56 can be a magnetic floppy disk or diskette. The hard disk drive 46, optical disk drive 50 and magnetic disk drive 52 communicate with the processing unit 34 via the bus 38. The hard disk drive 46, optical disk drive 50 and magnetic disk drive 52 may include interfaces or controllers (not shown) coupled between such drives and the bus 38, as is known by those skilled in the relevant art. The drives 46, 50 and 52, and their associated computer-readable media, provide nonvolatile storage of computer readable instructions, data structures, program modules and other data for the host computing system 12. Although the depicted host computing system 12 employs hard disk 46, optical disk 50 and magnetic disk 52, those skilled in the relevant art will appreciate that other types of computer-readable media that can store data accessible by a computer may be employed, such as magnetic cassettes, flash memory cards, digital video disks ("DVD"), Bernoulli cartridges, RAMs, ROMs, smart cards, etc.

Program modules can be stored in the system memory 36, such as an operating system 58, one or more application programs 60, other programs or modules 62 and program data 64. The system memory 36 may also include a Web client or browser 66 for permitting the host computing system 12 to access and exchange data with sources such as web sites of the Internet, corporate intranets, or other networks as described below, as well as other server applications on server computers such as those further discussed below. The browser 66 in the depicted embodiment is markup language based, such as Hypertext Markup Language (HTML), Extensible Markup Language (XML) or Wireless Markup Language (WML), and operates with markup languages that use syntactically delimited characters added to the data of a document to represent the structure of the document. A number of Web clients or browsers are commercially available such as NETSCAPE NAVIGATOR from America Online, and INTERNET EXPLORER available from Microsoft of Redmond, Washington

While shown in Figure 1 as being stored in the system memory 36, the operating system 58, application programs 60, other programs/modules 62, program data 64 and browser 66 can be stored on the hard disk 48 of the hard disk drive 46, the optical disk

54 of the optical disk drive 50 and/or the magnetic disk 56 of the magnetic disk drive 52. An operator, such as casino personnel, can enter commands and information into the host computing system 12 through input devices such as a keyboard 68 and a pointing device such as a mouse 70. Other input devices can include a microphone, joystick, game pad, scanner, etc. These and other input devices are connected to the processing unit 34 through an interface 72 such as a serial port interface that couples to the bus 38, although other interfaces such as a parallel port, a game port or a wireless interface or a universal serial bus ("USB") can be used. A monitor 74 or other display device is coupled to the bus 38 via a video interface 76, such as a video adapter. The host computing system 12 can include other output devices, such as speakers, printers, etc.

The host computing system 12 can operate in a networked environment using logical connections to one or more remote computers, such as the server computer 14. The server computer 14 can be another personal computer, a server, another type of computer, or a collection of more than one computer communicatively linked together and typically includes many or all of the elements described above for the host computing system 12. The server computer 14 is logically connected to one or more of the host computing systems 12 under any known method of permitting computers to communicate, such as through a local area network ("LAN") 78, or a wide area network ("WAN") or the Internet 80. Such networking environments are well known in wired and wireless enterprise-wide computer networks, intranets, extranets, and the Internet. Other embodiments include other types of communication networks including telecommunications networks, cellular networks, paging networks, and other mobile networks.

When used in a LAN networking environment, the host computing system 12 is connected to the LAN 78 through an adapter or network interface 82 (communicatively linked to the bus 38). When used in a WAN networking environment, the host computing system 12 may include a modem 84 or other device, such as the network interface 82, for establishing communications over the WAN/Internet 80. The modem 84 is shown in Figure 1 as communicatively linked between the interface 72 and

the WAN/Internet 78. In a networked environment, program modules, application programs, or data, or portions thereof, can be stored in the server computer 14. In the depicted embodiment, the host computing system 12 is communicatively linked to the server computer 14 through the LAN 78 or the WAN/Internet 80 with TCP/IP middle layer network protocols; however, other similar network protocol layers are used in other embodiments, such as User Datagram Protocol ("UDP"). Those skilled in the relevant art will readily recognize that the network connections shown in Figure 1 are only some examples of establishing communication links between computers, and other links may be used, including wireless links.

The server computer 14 is communicatively linked to the sensors, actuators, and gaming processors 86 of one or more gaming tables 18, typically through the LAN 78 or the WAN/Internet 80 or other networking configuration such as a direct asynchronous connection (not shown). The server computer 14 is also communicatively linked to the card distribution device 24, typically through the LAN 78 or the WAN/Internet 80 or other networking configuration such as a direct asynchronous connection (not shown).

The server computer 14 includes server applications 88 for the routing of instructions, programs, data and agents between the gaming processors 86 and the host computing system 12. For example the server applications 88 may include conventional server applications such as WINDOWS NT 4.0 Server, and/or WINDOWS 2000 Server, available from Microsoft Corporation or Redmond, Washington. Additionally, or alternatively, the server applications 88 can include any of a number of commercially available Web servers, such as INTERNET INFORMATION SERVICE from Microsoft Corporation and/or IPLANET from Netscape.

The gaming processor 86 can include gaming applications 90 and gaming data 92. The gaming applications 90 can include instructions for acquiring wagering and gaming event information from the live gaming at the game position, such as instructions for acquiring an image of the wagers and identifiers on playing cards. The gaming applications 90 can also include instructions for processing, at least partially, the acquired wagering and gaming event information, for example, identifying the position and size of

each wager and/or the value of each hand of playing cards. Suitable applications are described in one or more of commonly assigned U.S. patent applications: Serial No. 60/64368, filed April 21, 1999; Serial No. 09/474,858 filed December 30, 1999, entitled "METHOD AND APPARATUS FOR MONITORING CASINO GAMING" (Atty. Docket No. 54109.401); Serial No. 60/259,658, filed January 4, 2001; Serial No. 09/849456 filed May 4, 2001 (Atty. Docket No. 54109.402), Serial No. 09/790480, filed February 21, 2001, entitled "METHOD, APPARATUS AND ARTICLE FOR EVALUTING CARD GAMES, SUCH AS BLACKJACK" (Atty. Docket No. 54109.403).

Additionally, the gaming applications 90 may include statistical packages for producing statistical information regarding the play at a particular gaming table, the performance of one or more players, and/or the performance of the dealer 30 and/or game operator 66. The gaming applications 90 can also include instructions for providing a video feed of some or all of the gaming position. Gaming data may include outcomes of games, amounts of wagers, average wager, player identity information, complimentary benefits information ("comps"), player performance data, dealer performance data, chip tray accounting information, playing card sequences, etc. The gaming applications 90 can further include instructions for handling security such as password or other access protection and communications encryption. Thus, the server 12 can route wagering related information between the gaming tables and the host computing system 12.

Card Distribution Devices

Figure 4 shows one embodiment of the card distribution device 24, in the form of a first card printing device 24A.

The first card printing device 24A includes a housing 100 having a card receiver 102 for receiving playing card blanks 104, a card holder 106 for holding printed playing cards 108, and a card path identified by arrow 110 extending between the card receiver 102 and card holder 106. While shown as separate receptacles 102, 106, some embodiments of the card printing device 24A may employ a single receptacle both receiving the playing card blanks 104 and the printed playing cards 108. The first card

printing device 24A generally includes a drive mechanism 112, a print mechanism 114 and a control mechanism 116.

As illustrated in Figure 4, the drive mechanism 112 includes a drive roller 118 rotatably mounted at the end of a pivot arm 120 and driven by a motor 122 via a drive belt 124. The motor 122 can take the form of a stepper motor, that drives the drive roller 118 in small increments or steps, such that the card blank 104 is propelled incrementally or stepped through the card path 110 of the card distribution device 24A, pausing slightly between each step. Stepper motors and their operation are well known in the art. A spring 126 biases the pivot arm 120 toward the card blanks 104 to maintain contact between the drive roller 118 and an outside one 128 of the card blanks 104 in the card receiver 102. Thus, as the drive roller 118 rotates (counterclockwise with respect to the Figure), the outside card blank 128 is propelled along the card path 110. Additionally, or alternatively, a card support 130 positioned behind the card blanks 104 is supported along an inclined plane such as a guide channel 132 by one or more rollers 134. The weight of the card support 130 and or an additional attached weight (not shown) biases the card support 130 and the card blanks 104 toward the card path 110. The drive mechanism 112 also includes a number of guide rollers 136 to guide the card blank 104 along the card path 110. Typically the guide rollers 136 are not driven, although in some embodiments one or more of the guide rollers 136 can be driven where suitable. For example, one or more guide rollers 136 may be driven where the card path 110 is longer than the length of the card blank 104. While a particular drive mechanism 112 is illustrated, many other suitable drive mechanisms will be apparent to those skilled in the art of printing. Reference can be made to the numerous examples of drive mechanisms for both impact and non-impact printers.

The printing mechanism 114 includes a print head 138 and a platen 140. The print head 138 can take any of a variety of forms, such as a thermal print head, ink jet print head, electrostatic print head, or impact print head. The platen 140, by itself or with one or more of the guide rollers 136 (*i.e.*, "bail rollers"), provides a flat printing surface on a card blank 104 positioned under the print head 138. While illustrated as a platen roller

140, the first card printing device 24A can alternatively employ a stationary platen where suitable for the particular card stock and print head 138. In an alternative embodiment, the platen roller 140 may be driven by the motor 122, or by a separate motor.

The control mechanism 116 includes a microprocessor 142, volatile memory such as a Random Access Memory ("RAM") 144, and a persistent memory such as a Read Only Memory ("ROM") 146. The microprocessor 142 executes instructions stored in RAM 144, ROM 146 and/or the microprocessor's 142 own onboard registers (not shown) for generating a random playing card sequence, and printing the appropriate markings on the playing cards in the order of the random playing card sequence. The control mechanism 116 also includes a motor controller 148 for controlling the motor 112 in response to motor control signals from the microprocessor 142, and a print controller 150 for controlling the print head 138 in response to print control signals from the microprocessor 142.

The control mechanism 116 may further include a card level detector 152 for detecting a level or number of playing cards in the playing card holder 106. The card level detector 152 can include a light source and receiver pair and a reflector spaced across the playing card holder from the light source and receiver pair. Thus, when the level of playing cards 108 in the card holder 106 drops below the path of the light, the card level detector 152 detects light reflected by the reflector, and provides a signal to the microprocessor 142 indicating that additional playing cards 108 should be printed. The printing device 24B can employ other level detectors, such as mechanical detectors.

In operation the microprocessor 142 executes instructions stored in the RAM 144, ROM 147 and/or microprocessor's registers to computationally generate a random playing card sequence from a set of playing card values. Random number generation on computers is well known in the computing arts. Mathematicians do not generally consider computer generated random numbers to be truly random, and thus commonly refer to such numbers as being pseudo-random. However such numbers are sufficiently random for most practical purposes, such as distributing playing cards to players. Hence, while we denominate the computer generated values as being pseudo-

random, such term as used herein and in the claims should include any values having a suitable random distribution, whether truly mathematically random or not.

The microprocessor 142 generates print data based on the computationally generated random playing card sequence. The print data consists of instructions for printing markings on respective ones of the playing card blanks 104 that correspond to respective playing card values from the random playing card sequence. For example, the print data can identify which elements of the print head 138 to activate at each step of the motor 122 to print a desired image. During each pause between steps of the motor 122, a small portion of the card blank 104 is aligned with the print head 138 and selected elements of the print head 138 are activated to produce a portion of an image on the portion of the card blank 104 aligned with the print head 138. The image portion is a small portion of an entire image to be printed. The entire image typically is produced by stepping the card blank 104 past the print head 138, pausing the card blank 104 after each step, determining the portion of the image corresponding to the step number, determining which elements of the print head 138 to activate to produce the determined portion of the image, and activating the determined elements to produce the determined portion of the image on the card blank 104. The microprocessor 142 provides the print data as motor commands to the motor controller 148 and as print commands to the print controller 150, for respectively synchronizing and controlling the motor 122 and print head 138.

Thus, the card printing device 24A of Figure 4 provides a standalone card distribution device for printing playing cards in a pseudo-random sequence, which may be used at any gaming position. Since the first card printing device 24A includes a microprocessor 142, the first card printing device 24A is particularly suited for the manually monitored gaming table 18 of Figure 2, where the card distribution device 24 operates in a standalone mode. However, the first card printing device 24A can operate as an integral portion of the automated wager monitoring system 10, or in conjunction with such a system 10.

As shown in Figure 5, the markings on the playing cards 108 (Figure 4) may include the conventional symbols representing a rank (*i.e.*, 2-10, Jack, Queen, King, Ace)

154 and a suit (*i.e.*, Diamonds, Hearts, Spades and Clubs) 156 of the playing card (shown in Figure 5). The markings can also include indicia such as the images of Jacks, Queens and Kings 158 commonly found on playing cards.

The markings may also include an identifier, for example a serial number that uniquely defines the particular playing, and/or playing card deck to which the playing card belongs. The identifier can take the form of a bar code, area code or stack code symbol 160 selected from a suitable machine-readable symbology, to allow easy machine recognition using standard readers. While visible in the illustration, the bar code symbols 160 can be printed with an ink that is only visible under a specific frequency of light, such as the UV range of the electromagnetic spectrum. This prevents players 26 from viewing the serial numbers during game play.

The markings can optionally include additional indicia such as advertising messages 162. The advertising messages 162 may be player or game specific, and may be provide to only specific players, to random players, and/or to all players. The advertising message 162 may take the form of promotions, for example, informing the player that the card may be redeemed for meals, beverages, accommodations, souvenirs, goods and/or services at casino facilities or other facilities. The inclusion of a serial number on the playing card, particularly a serial number encoded in machine-readable form 160 allows a promotional playing card 164 of the playing cards 108 to be easily verified using standard automatic data collection ("ADC") devices when presented for redemption.

Figure 6 shows another embodiment of the card distribution device 24, in the form of a second card printing device 24B. The second card printing device 24B generally includes a read mechanism 166, an erase mechanism 168, a drive mechanism 170, a print mechanism 172, and a control mechanism 174.

A set of playing cards 108 located in the card receiver 102 includes identifying markings previously printed on playing card blanks. The identifying markings include a markings 154 corresponding to a rank, markings 156 corresponding to a suit, and markings 160 in the form of machine-readable bar code symbols 160 encoding a unique serial number identifying the particular card and/or deck of playing cards. While visible in

the illustration, the bar code symbols 160 may be printed with an ink that is only visible under a specific frequency of light, such as the UV range of the electromagnetic spectrum to prevent identification by the player 26.

The read mechanism 166 includes a light source 176 and a reader head 178 for imaging the identifying markings 154, 156, 160 on the playing cards. The read mechanism 166 may also include optical components such as mirrors, reflectors, lenses, filters and the like.

The light source 176 may be selectively operated in response to a read command received from the host computing system 12, and/or in response to the presence of playing cards 108 in the card receiver 102. The read mechanism 166 may include a card presence detector 180 that determines when there is one or more playing cards 108 in the card receiver 102. The card presence detector 180 may take the form of a light source directing light to a reflector across the card receiver 102, and a light detector to receive the reflected light. The presence of playing cards 108 in the card receiver 102 interrupts the light, which can trigger the light source 176 directly, and/or send an appropriate signal to the host computing system 12 which may transmit a return signal to trigger the light source 176. Likewise, the reader head 178 may also be triggered directly by the card presence detector 180, or indirectly via the host computing system 12. Alternatively, in certain embodiments, the reader head 178 may remain in an ON or active state, relying on the activation of the light source 176 to capture images of the playing cards 108 in the card receiver 102.

In one embodiment, the reader head 178 includes an area imager capable of imaging a two-dimensional area encompassing the machine-readable symbols 160 on each of the playing cards in a single image. For example the reader head 178 may include a two-dimensional array of charge coupled devices ("CCDs").

In another embodiment the reader head 178 can take the form of a linear imager having a field-of-view that can be swept across the machine-readable symbols 160 on each of the playing cards 108 in succession. The read mechanism 166 may employ any of a variety of methods and structures for sweeping the field-of-view of the reader head

178. For example, the reader head 178 can be pivotally mounted for movement with respect to the playing cards 108. Alternatively, a mirror or other optical component (not shown) can be pivotally mounted for movement with respect to the reader head 178 and the playing cards 108. Alternatively, the light source 176 can be pivotally mounted for movement with respect to the playing cards 108. Alternatively, a mirror or other optical component (not shown) can be pivotally mounted for movement with respect to the light source 176 and the playing cards 108.

In yet another embodiment, the reader head 178 and field-of-view of the reader head 178 may remained fixed while the playing cards 108 are transported past the field-of-view of the reader head 178.

In a further embodiment, the reader head 178 can take the form of a scanner, such as a laser scanner, for acquiring the machine-readable symbols 160. In such an embodiment the reader head 178 would include a laser light source, photo-detector, amplifier and wave shaper. Laser scanners typically do not employ additional light sources, such as the light source 176.

The construction and operation of imagers and scanners for reading machine-readable symbols is generally known in the field of automatic data collection ("ADC"), so will not be described in further detail in the interest of brevity. The structure and operation of machine-readable symbol readers is generally discussed in *The Bar Code Book*, Palmer, Roger, C., Helmers Publishing, Inc., Peterborough, New Hampshire (Third Edition).

An erase mechanism 168 includes an erase head 182 positionable to erase selected markings on a playing card 108. In a simple embodiment, the erase head 182 includes a rotatably mounted eraser 184 and a motor 186 coupled to rotate the eraser 184 while the eraser is in contact with the playing card 108. The eraser 184 may have a cylindrical shape, with a longitudinal axis perpendicular to the card path 110.

The drive mechanism 170 includes a motor 122 coupled to directly drive a platen roller for advancing playing cards 108 along the playing card path 110. The drive

mechanism 170 may also include guide rollers 136 for orienting and guiding the playing cards 108 along the playing card path 110.

The print mechanism 172 includes a first print head 188 and a second print head 190. The first print head 188 can print visible markings on the playing card, while the second print head 190 prints invisible markings (*e.g.*, marking only visible under UV light) on the playing card. Two print heads 188, 190 may be particularly suitable where the print heads 188, 190 are ink jet print heads, requiring separate reservoirs of ink for printing visible and invisible markings. The print mechanism 172 may include additional or fewer print heads depending on the particular printing requirements. For example, the print mechanism 172 may employ separate print heads for red and black ink, or may employ additional print heads for other colors that make up the graphics on the playing cards. Alternatively, the print mechanism 172 may employ a single print head capable of handling multiple colors (*e.g.*, color thermal printing, dye sublimation printing). The print heads 188, 190 receive print control signals from the control mechanism 174, such as signals identifying which print elements (not shown) of the print heads 188, 190 to activate at a particular time or position.

The control mechanism 174 includes a controller 192 that couples the various other components to a communications port 194 via an Input/Output ("I/O") buffer 196. The communications port 194 can take the form of any of a variety of communications ports such as D9 connector employing an RS232 protocol. The communications port 194 can allow communications with the host computing system 12 via the LAN 78 and/or WAN 80. The I/O buffer 196 serves as a holding area for data coming into and going out of the communications port 194. The controller 192 routes data, and can perform simple control functions. While the card printing device 24B may employ a microprocessor such as the microprocessor 142 (Figure 4), a controller 192 provides a less expensive alternative, particularly where the network environment permits much of the processing to be distributed to other devices, for example to the host computing system 12.

The control mechanism 174 may also include a card level detector 152 for detecting a level or number of playing cards in the playing card holder 106. The card level

detector 152 can include a light source and receiver 198 and a reflector 200 spaced across the playing card holder 106 from the light source and receiver 198. Thus, when the level of playing cards drops below the path of the light, the light sources and receiver 198 detects light reflected by the reflector 200, and the card level detector 152 provides a signal to the host computing system 12 via the controller 192 indicating that additional playing cards should be printed. The printing device 24B can employ other card level detectors, such as mechanical detectors.

The control mechanism 174 includes a printing controller 202 coupled to control the motor 122 and the print heads 188, 190.

In operation in the embodiment of Figure 6, the host computing system 12 determines the playing card values and generates the pseudo-random playing card sequence. The host computing system 12 also generates the print data and provides the print data to the printing controller 202 via the controller 192 to control and synchronize the operation of the motor 122 and print heads 188, 190. The print data consists of instructions for printing markings on respective ones of the playing cards 108, after the playing cards have been erased, that correspond to respective playing card values from the random playing card sequence generated by the host computing system 12. Alternatively, the host computing system 12 can provide motor control signals and print control signals directly to the motor 122 and print heads 188, 190 via the controller 192. In a further alternative, the controller 192 can be configured to also serve as a printing controller, receiving the print data and providing the motor control signals and print control signals the motor 122 and print heads 188, 190. In yet a further alternative, the host computing system 12 can provide print data to a motor controller and print controller, such as the motor controller 148 and print controller 150 shown in Figure 4, for controlling the motor 122 and print heads 188, 190, respectively.

Since the card printing device 24B receives data such as a random playing card sequence from the host computing system 12 and/or print data, the card printing device 24B of Figure 5 may be a relatively low cost device, employing a simple controller 192 and/or print controller 202 rather than a relatively more expensive microprocessor.

Thus, the card printing device 24B is particularly suited for use with the networked automated wager monitoring system 10 of Figure 1. Thus, the card printing device 24B provides an integrated networked device for printing playing cards in a pseudo-random sequence.

The card printing device 24B also reads the playing cards 108 in the card receiver 102, allowing the tracking of playing and wagering according to methods described in commonly assigned U.S. patent applications: Serial No. 60/130,368, filed April 21, 1999; Serial No. 09/474,858, filed December 30, 1999, entitled "METHOD AND APPARATUS FOR MONITORING CASINO GAMING" (Atty. Docket No. 120109.401); Serial No. 60/259,658, filed January 4, 2001; Serial No. 09/849,456, filed May 4, 2001 (Atty. Docket No. 120109.402); and Serial No. 09/790,480, filed February 21, 2001, entitled "METHOD, APPARATUS AND ARTICLE FOR EVALUTING CARD GAMES, SUCH AS BLACKJACK" (Atty. Docket No. 120109.403). Additionally, the card printing device 24B reuses playing cards 108, erasing previous markings after reading the playing cards 108 and before printing new markings on the playing cards 108.

Real-time, or almost real time playing card printing may realize a number of distinct advantages over mechanical shufflers. For example, the playing card printing devices 24A, 24B can employ an unlimited number of "virtual" card decks (*i.e.*, playing card values) in creating the random playing card sequence, only printing the limited number of physical playing cards required for playing a game. For example, the playing card printing device 24A, 24B can receive or generate, respectively, the random playing card sequence from 500 decks of cards or more, yet print only one or two decks of playing cards, or as few hands of playing cards, as needed. The playing card printing device 24A, 24B may also produce a more truly random sequence than a mechanical shuffler, which is prone to incomplete shuffling due to the inherent consistencies of mechanical systems. The card printing devices 24A, 24B may also increase the speed of play since the card printing devices 24A, 24B eliminate the need for repeated mechanical manipulations of the playing cards.

Wagering System Operation

Figures 7A-7B show a method 300 of operation for the playing card printing device 24B of Figure 6, starting in step 302. While discussed below in terms of remote operation by the host computing system 12, an appropriately configured card printing device 24B could execute some or all of those functions. Portions of the method 300 are also applicable to the playing card printing device 24A of Figure 4.

In step 304, the card printing device 24B reads machine-readable symbols 160 from the playing cards 108 in the card receiver 102 employing the reader head 178, as generally described above. One skilled in the art will recognize the rank and suit markings 154, 156 could be read, however the machine-readable symbols are typically easier to process with existing hardware and software. In step 306, the host computing system 12 processes the previous hands based on the identifiers encoded in the read machine-readable symbols 160. The host computing system 12 can employ methods and apparatus taught in commonly assigned U.S. patent applications U.S. patent applications: Serial No. 60/130,368, filed April 21, 1999; Serial No. 09/474,858, filed December 30, 1999, entitled "METHOD AND APPARATUS FOR MONITORING CASINO GAMING" (Atty. Docket No. 120109.401); Serial No. 60/259,658, filed January 4, 2001; Serial No. 09/849,456, filed May 4, 2001 (Atty. Docket No. 120109.402); and Serial No. 09/790,480, filed February 21, 2001, entitled "METHOD, APPARATUS AND ARTICLE FOR EVALUTING CARD GAMES, SUCH AS BLACKJACK" (Atty. Docket No. 120109.403).

In step 308, the host computing system 12 determines the casino advantage for the game. Typically, the casino advantage is dependent on a number of factors, including the type of card game, the particular rules employed by the casino for the type of card game, and the number of decks or cards from which the cards are dealt. In an alternative embodiment, the casino advantage may also depend on the composition of those playing card decks where, for example, certain playing cards are removed or added to the card decks (*e.g.*, 5 Aces in one or more card decks; and/or only 3 Kings in one or more card decks). The host computing system 12 may rely on a previously defined game type, game

rules and number of decks, or may allow the dealer 30, or even the player 26, to select one or more of the parameters. For example, the dealer 30 may select the desired advantage and provide suitable house odds to the player 26 based on the advantage. Alternatively, the player 26 may select a set of desired house odds, and rely on the host computing system 12 to select the appropriate casino advantage corresponding to those house odds. Thus, the casino can offer the player 26 higher odds where the player 26 is willing to play against a hand dealt from a larger number of playing cards 108. The casino can also offer the player 26 higher odds where certain playing cards are omitted from one or more card decks. Additionally, or alternatively, the casino can offer the player higher odds or a bonus for receiving a particular hand, such as 5 sevens.

In step 310, the host computing system 12 determines the number of decks of playing cards required to deal a game having the determined casino advantage. In step 312, the host computing system 12 determines a set of playing card values based on the determined number of card decks. Typically, the host computing system 12 will employ one playing card value for every playing card rank and suit combination for each of the determined number of playing card decks (*e.g.*, 52 playing card values per card deck). Thus, the host computing system 12 is working with "virtual" playing cards, or values representing playing cards in one or more "virtual" decks.

The playing card values can take any of a variety of forms which is capable of identifying each individual playing card, and which is convenient for computational use. For example, each playing card in a conventional deck can be assigned an integer value 1-52. Successive integers can be assigned where more than one card deck is used. For example, each playing card rank and suit combination in a second conventional deck can be assigned a respective integer playing card value from 53 to 104. The playing card rank and suit combinations in each "virtual" card deck may be in a matching predefined sequence. For example, the playing card value corresponding to the two of hearts combination may be 1 for the first deck and 53 for the second deck, while the playing card value for the Ace of spades may be 52 for the first deck and 104 for the second deck. Employing the same sequence for mapping the playing card values to the rank and suit

combinations in multiple "virtual" card decks facilitates later card identification or recognition, while not hindering the generation of pseudo-random sequences.

In step 314, the host computing system 12 generates a pseudo-random playing card sequence from the determined playing card values. Methods of random number generation are well known in the computer arts so will not be described in detail. The random number generation employs a range initially including all of the determined playing card values. Thus, the host computing system 12 can generate a random sequence that is unaffected by mechanical consistencies of any device, or mechanical limitations on the total number of playing cards.

In step 316, the host computing system 12 determines identifiers for the playing cards 108, such as unique serial numbers. The identifier can uniquely identify the particular playing card, and/or the card deck to which the playing card belongs. A non-sequential assignment of identifiers may enhance security. In an alternative embodiment, discussed below, the machine-readable symbols 160 encoding the identifiers remain printed on the card blanks, thus new identifiers do not need to be determined.

In step 318, the host computing system 12 creates logical associations between the identifiers and the playing card values. For example, the host computing system 12 can store the logical association between playing card values and respective identifiers as a database stored in a computer-readable memory. The logical association maps the playing card values, and hence the rank and suit markings 154, 156 to be printed on a playing card 108, with the identifier which is to be printed on the same playing card 108 in the form of a machine-readable symbol 160.

In step 320, the host computing system 12 determines the print data based on the playing card values and identifiers. As discussed above, the print data includes the specific instructions for printing the various markings 154, 156 and/or 160 on the corresponding playing cards 108. In an alternative embodiment, the printing controller 202 can determine the print data based on the playing card values, identifier or other information supplied by the host computing system 12. For example, a computer-readable memory (not shown) in the card printing device 24B can store print data for each of the 52

different playing card faces in a typical card deck. A portion or all of the playing card value supplied by the host computing system 12 can identify the appropriate print data to the printing controller 202 for printing the corresponding playing card 108.

Where the host computing system 12 performs steps 316, 318 and/or 320 immediately after the step of determining the random playing card sequence 314, the host computing system 12 may determine the identifiers, create the logical associations and determine the print data for all of the playing card values in the random card sequence. Alternatively, the steps 316, 318 and/or 320 can be performed for smaller sets of playing cards, or even on a card-by-card basis, for example immediately before each playing card is printed. Thus, identifiers will not be assigned for cards which may never be used in play with the consequent benefit of conserving unique identifiers. This approach may also reduce the load on the host computing system 12, with consequent benefits in reduced infrastructure and/or increased operating speed.

The host computing system 12 and/or printing controller 202 initializes various counters in preparation for printing the physical playing cards 108 according to the computationally generated pseudo-random playing card sequence of playing card values. For example, in step 322 the host computing system 12 and/or printing controller 202 sets a first counter J equal to 0 (*i.e.*, J = 0). In step 324, the host computing system 12 and/or printing controller 202 sets a second counter I equal to a number of cards to be burned (*e.g.*, I = 3). Casinos typically skip an initial number of playing cards when dealing from a freshly shuffled card deck in a procedure commonly reference to as "burning the cards." This hinders a player's ability to accurately count cards. Setting the first counter J equal to the number of cards to be burned, prevents the card printing device 24B from printing these playing cards, possibly saving playing card blanks, ink and/or time. Alternatively, the number of playing cards to be burned can be set equal to 0, and the dealer 30 may physically discard an appropriate number of playing cards 108 prior to dealing. Casinos may find this method preferable as a visible deterrent to card counting, and/or to make the card game appear as similar as possible to conventionally dealt cards games.

In step 326, the host computing system 12 and/or printing controller 202 increments the second counter I (*i.e.*, I=I+1) in preparation for printing the next playing card. In step 328, the drive mechanism 170 of the card printing device 24B transports a playing card 108 along the card path 110, employing the motor 122 as discussed generally above. In step 330, the erase mechanism 168 of the card printing device 24B erases the markings 154, 156, from the face of the playing card employing the erasure head 182 as generally described above. In some embodiments, the machine-readable symbol 160 may be erased in preparation to providing a new machine-readable symbol 160 encoding a new identifier such as a unique serial number. This procedure may provide enhanced security, making it more difficult to obtain the identifiers. In other embodiments, the machine-readable symbol 160 can be left in tact, and a new logical association made between the identifier or serial number encoded in the machine-readable symbol 160 and the new playing card value and/or the rank and suit markings 154, 156 assigned to the particular playing card 108.

In step 332, the print mechanism 172 of the card printing device 24B prints new markings 154, 156, and/or 160 on the playing card 108 employing the printing heads 188, 190.

In step 334, the host computing system 12 and/or printing controller 202 determines whether the second counter I is greater than a set size value. The set size value can be set to any convenient size. For example, the set size can be set to 52 playing cards where playing cards will be dealt from a handheld deck by the dealer 30. If the second counter is not greater than the set size, control returns to step 350, where the second counter I is incremented in preparation for the next playing card. If the second counter is greater than the set size, control passes to step 348.

In step 336, the host computing system 12 and/or printing controller 202 determines whether there are sufficient playing card values remaining in the playing card sequence to print the next set of playing cards. Thus, the host computing system 12 and/or printing controller 202 assesses deck penetration (*i.e.*, how many cards remain to be dealt). One way of assessing deck penetration is to determine whether the current card count is

equal to or greater than the total number of cards multiplied by a deck penetration percentage. A suitable mathematical formula for such is given as: J * Set Size + I ≥ ((52 * Number of Decks) - Number of Burned Cards) * Percentage. Alternatively, the penetration can be represented as a number of cards that are not to be dealt. Thus, the mathematical representation would be given as: J * Set Size + I ≥ ((52 * Number of Decks) - Number of Burned Cards) - Number of Cards To Not Be Dealt.

If the host computing system 12 and/or printing controller 202 determine that the deck has been sufficiently penetrated, control passes to step 338 where the method terminates, although the method 300 may execute in a continuous loop, or in a multi-threaded fashion as suits the particular environment. The method 300 can then be restarted to produce a new set of playing cards in a pseudo-random sequence. If the host computing system 12 and/or printing controller 202 determine that the card deck 108 has not been sufficiently penetrated, control passes to step 340. In step 340, the host computing system 12 and/or printing controller 202 determine whether additional playing cards 108 should be printed. For example, the host computing system 12 and/or printing controller 202 can check the status of the card level detector 152 to determine whether a sufficient number of playing cards remain in the card holder 106.

If there are not sufficient playing cards control passes to step 342. If there are sufficient playing cards remaining, the controller 192 and/or host computing system 12 determines whether a reset has been requested, in step 344. A reset may be automatically requested, for example in response to an occurrence of an error condition, or may be manually requested. A manual request may occur, for example, by the dealer 30 selecting a reset or new shuffle switch when the dealer wishes to deal from a new set of cards. The dealer 30 or other casino personnel may select this option when, for example, the dealer 30 suspects the player 26 of card counting. If a reset condition has occurred, control is passed to step 338, where the method ends. If a reset condition has not occurred, the host computing system 12 and/or printing controller 202 execute a wait loop 346, returning control back to step 340.

In step 342, the host computing system 12 and/or printing controller 202 increments the first counter J, and in step 348 initializes the second counter I (*i.e.*, I=0), in preparation for printing the next set of playing cards. The host computing system 12 and/or printing controller 202 passes control back to step 326 to print the next playing card 108.

While the embodiment of Figures 7A-7B employs the host computing system 12 for the primary portion of the processing, the processing may be distributed to other computing systems and/or processors distributed throughout a casino, or associated with one or more of the gaming tables 18. Distributing the processing may reduce the workload on the host computing system, allowing a smaller processor to handle more wagering, and perhaps providing faster results. However, retaining processing at the host computing system 12 may provide better control over the software, and may make changes to the software simpler. The above described system may also employ a mix of the above approaches, for example, retaining processing at the host computing system 12 for some aspects such as random number generation, while distributing the processing to card printing device 24A, 24B for other aspects such as generating print data and/or printing.

Figures 8A-8B show a method 400 of operation for the playing card printing device 24A of Figure 4, starting in step 402. While discussed below in terms of remote operation by the microprocessor 142, an appropriately configured card printing device 24A could distribute some or all of those functions to an external computing system or processor such as a host computing system 12. Portions of the method 400 are similar to the method 300 of Figures 7A-7B, thus common acts and structures will be identified using similar reference numbers, differing only in the most significant digit (*e.g.*, 312 is similar to 412), and only significant difference in operation will be discussed below.

The method 400 starts in step 402. In step 408, the microprocessor 142 determines the casino advantage for the game. Determining the casino advantage is been discussed in detail above.

In step 410, the microprocessor 142 determines the number of decks of playing cards required to deal a game having the determined casino advantage. In step 412, the microprocessor 142 determines a set of playing card values based on the

determined number of card decks. In step 414, the microprocessor 142 generates a pseudo-random playing card sequence from the determined playing card values. In step 416, the microprocessor 142 determines identifiers for the playing cards 108, such as unique serial numbers. In optional step 418, the microprocessor 142 creates logical associations between the identifiers and the playing card values. In step 420, the microprocessor 142 determines the print data based on the playing card values and identifiers. The steps 416, 418 and/or 420 may be performed for smaller sets of playing cards, or even on a card-by-card basis, for example immediately before each playing card is printed. In step 424, the microprocessor 142 sets a first counter I equal to a first playing card value, including any of a number of cards to be burned (*e.g.*, I = 3). In step 428, the drive mechanism 112 (Figure 4) of the card printing device 24A transports a playing card 108 along the card path 110. In step 432, the print mechanism 114 (Figure 4) of the card printing device 24A prints new markings 154, 156, and/or 160 on the playing card 108 employing the printing head 138.

In step 434, the microprocessor 142 determines whether there are additional playing card values in the random sequence of playing cards. For example, the microprocessor 142 can determine whether the first counter I is equal to or greater than the total number of playing card values minus any burned cards and/or reserved cards (*e.g.*, card penetration). If the there are additional playing cards, control passes to step 426, where the first counter I is incremented (I = I + 1) in preparation for printing the next playing card. If there are no additional playing card values, the method 400 terminates in step 438, or alternatively returns to the start 402 to continuously execute.

Although specific embodiments of and examples for the card distribution device and method of operating the same are described herein for illustrative purposes, various equivalent modifications can be made without departing from the spirit and scope of the invention, as will be recognized by those skilled in the relevant art. The teachings provided herein of the invention can be applied to any networked systems, including the World Wide Web portion of the Internet. The teachings can also employ standalone systems, and/or to combinations of standalone and networked card distribution devices 24

in the same gaming environment. The teachings can apply to any type of card game where a random distribution of playing cards is desired, such as baccarat, 5-card stud poker, Caribbean stud poker, Tai Gow poker, Hi/Low, and Let-It-Ride™. While the illustrated embodiments show networked and standalone embodiments, the invention is not limited to such, and one skilled in the art can easily adapt the teachings herein to further levels of wagering. The card distribution device 24 can be used with a larger number of players. The card distribution device 24 can be used in environments other than casinos, such as taverns, betting parlors, and even homes. Additionally, the methods described above may include additional steps, omit some steps, and perform some steps in a different order than illustrated.

The teachings can also be adapted to employ playing cards formed of "smart paper," a product developed by Xerox Palo Alto Research Center, of Palo Alto, California. The smart paper consists of a flexible polymer containing millions of small balls and electronic circuitry. Each ball has a portion of a first color and a portion of a second color, each portion having an opposite charge from the other portion. Applying a charge causes the balls to rotate within the polymer structure, to display either the first or the second color. Charges can be selectively applied to form different ones or groups of the balls to from the respective markings 154-160 on the playing cards 108. The markings 154-160 remain visible until another charge is applied.

Alternatively, the teachings can be adapted to employ color-changing inks such as thermochromatic inks (*e.g.*, liquid crystal, leucodyes) which change color in response to temperature fluctuations, and photochromatic inks that respond to variations in UV light.

The various embodiments described above can be combined to provide further embodiments. All of the above U.S. patents, patent applications and publications referred to in this specification as well as commonly assigned U.S. Serial No. 60/296,866, filed June 8, 20001, entitled "METHOD, APPARATUS AND ARTICLE FOR RANDOM SEQUENCE GENERATION AND PLAYING CARD DISTRIBUTION" (Atty. Docket No. 120109.406P1) are incorporated herein by reference. Aspects of the invention can be

modified, if necessary, to employ systems, circuits and concepts of the various patents, applications and publications to provide yet further embodiments of the invention.

While the illustrated embodiment typically discusses decks of playing cards, some embodiments may employ a lesser or greater number of playing cards, or can employ playing cards and/or decks other than the conventional playing card decks (*i.e.*, 52 cards with ranks 2-10, Jack, Queen, King, and Ace and with four suits, heats, diamonds, spades and clubs).

These and other changes can be made to the invention in light of the above detailed description. In general, in the following claims, the terms used should not be construed to limit the invention to the specific embodiments disclosed in the specification and the claims, but should be construed to include all card distribution devices and method that operate in accordance with the claims. Accordingly, the invention is not limited by the disclosure, but instead its scope is to be determined entirely by the following claims.